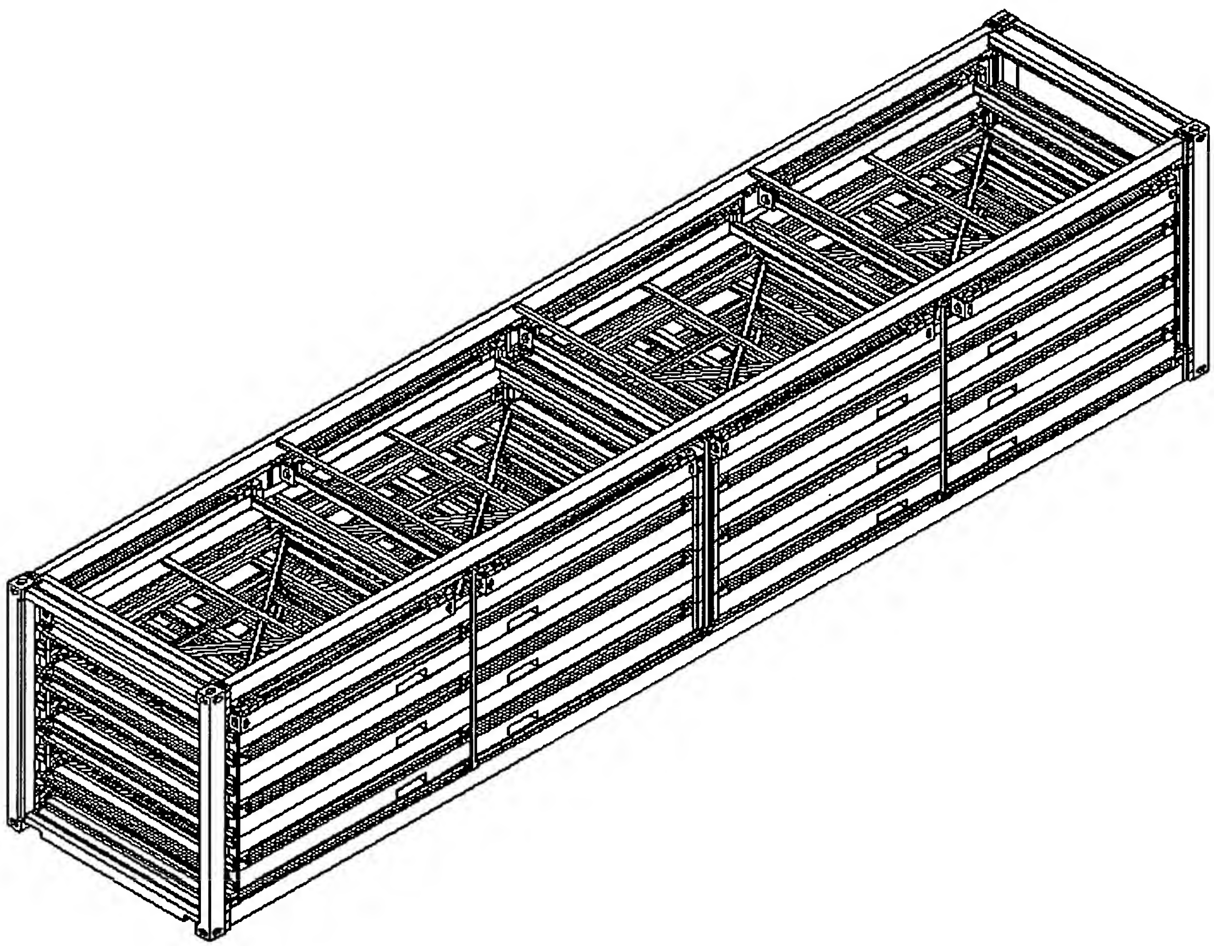
THE COLLAPISIBLE CARGO CONTAINER



CROSS-REFERENCE TO RELATED APPLICATIONS

[1] This application claims the benefit of U.S. Provisional Application No. 60/451,503 filed March 3, 2003, which is hereby incorporated herein by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCE TO SEQUENCE LISTING, A TABLE, OR A COMPUTER PROGRAM LISTING COMPACT DISK APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

1.Field of the Invention

[2] The present invention is directed to the empty cargo container repositioning in the logistics industry.

2.Prior Art

[3] Trades among different continents create the need for the empty cargo container repositioning. Take the trade between North America and Asia as an example; cargo containers are fully loaded with goods manufactured in Asia when transported from Asia to North America; however, most of those cargo containers are empty when transported from North America back to Asia. The empty cargo container repositioning is fairly costly because it involves similar operations as the loaded one during its transportation from one location to another.

[4] The collapsible cargo container is designed to reduce the empty cargo container repositioning by converting a collapsible cargo container itself into cargo to be shipped during the empty cargo container repositioning; therefore, this characteristic of the invention will become apparent in light of the present specification, including claims, and drawings.

BRIEF SUMMARY OF THE INVENTION

[5] The present invention designs a collapsible cargo container consisting of six component frame panels; the six component frame panels are a floor frame panel, a ceiling frame panel, two identical front and back frame panels, a right frame panel where the doors located and a left frame panel. During empty cargo container repositioning, each empty collapsible cargo container is disassembled into six component frame panels, and the component frame panels are loaded into shipping collapsible cargo containers, then shipped to a destination. After the shipping collapsible cargo containers arrive at the destination, the disassembled component frame panels will remain in the shipping collapsible cargo containers until needed. Compared to the traditional cargo container, the collapsible cargo container has a new unique feature, i.e. it can be shipped as cargo, which reduces the empty cargo container repositioning cost as well as the space demand in container yards.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[6] The foregoing summary and the following detailed description may be better understood when read in conjunction with the accompanying drawings. Various embodiments are shown for the purpose of illustrating the invention. It is understood, however, that this invention is not limited to the precise arrangements shown. A drawings identification is based on the cargo container type, that is, FIG. 3A represents a 40 foot cargo container drawing; FIG. 3B represents a 40 foot high cube cargo container drawing; FIG. 3C represents a 20 foot cargo container drawing; FIG. 3D represents a 20 foot high cube cargo container drawing; FIG. 33A/B represents a drawing for 40 foot cargo container and 40 foot high cube cargo container; FIG 33C/D represents a drawing for 20 foot cargo container and 20 foot high cube cargo container; FIG 39A/C/D represents a drawing for 40 foot cargo container, 20 foot cargo container and 20 foot high cube cargo container; FIG 54 represents a drawing for all type container. Furthermore, a floor frame panel coat, a ceiling frame panel coat, a front frame panel coat, a back frame panel coat, a left frame panel coat and two right frame panel doors are not presented in drawings in order to show the invention clearly.

[7] FIG. 1A ("Drawings" page 1) shows a basic isometric view of the 40 foot collapsible cargo container loaded with three disassembled 40 foot collapsible cargo container frames.

[8] FIG. 2A ("Drawings" page 2) shows a detailed isometric view of the 40 foot collapsible cargo container loaded with three disassembled 40 foot collapsible cargo container frames.

[9] FIG. 3A ("Drawings" page 3) shows a basic isometric view of the 40 foot collapsible cargo container frame.

[10] FIG. 4A ("Drawings" page 4) shows an enlarged isometric view of the left end of a 40 foot collapsible cargo container.

[11] FIG. 5A ("Drawings" page 5) shows an opaque isometric view of the 40 foot collapsible cargo container frames.

[12] FIG. 6A ("Drawings" page 6) shows a basic isometric view of the floor frame (40 foot collapsible cargo container).

[13] FIG. 7A ("Drawings" page 7) shows an opaque isometric view of the floor frame (40 foot collapsible cargo container)

[14] FIG. 8A ("Drawings" page 8) shows an isometric view of the left end of the floor frame (40 foot collapsible cargo container).

[15] FIG. 9A ("Drawings" page 9) shows a top view of the left end of a floor frame (40 foot collapsible cargo container).

[16] FIG. 10A ("Drawings" page 10) shows a front view of the left end of a floor frame (40 foot collapsible cargo container).

[17] FIG. 11A ("Drawings" page 10) shows a left view of a floor frame (40 foot collapsible cargo container).

[18] FIG. 12A ("Drawings" page 11) shows an isometric view of the right end of a floor frame (40 foot collapsible cargo container).

[19] FIG. 13A ("Drawings" page 12) shows a top view of the right end of a floor frame (40 foot collapsible cargo container).

[20] FIG. 14A ("Drawings" page 13) shows a front view of the right end of a floor frame (40 foot collapsible cargo container).

[21] FIG. 15A ("Drawings" page 13) shows a right view of a floor frame (40 foot collapsible cargo container).

[22] FIG. 16A ("Drawings" page 14) shows an isometric view of a ceiling frame (40 foot collapsible cargo container).

[23] FIG. 17A ("Drawings" page 15) shows an isometric view of the left end of a ceiling frame (40 foot collapsible cargo container).

[24] FIG. 18A ("Drawings" page 16) shows a top view of the left end of a ceiling frame (40 foot collapsible cargo container).

[25] FIG. 19A ("Drawings" page 17) shows a front view of the left end of a ceiling frame (40 foot collapsible cargo container).

[26] FIG. 20A ("Drawings" page 17) shows a left view of a ceiling frame (40 foot collapsible cargo container).

[27] FIG. 21A ("Drawings" page 18) shows an isometric view of the right end of a ceiling frame (40 foot collapsible cargo container).

[28] FIG. 22A ("Drawings" page 19) shows a top view of the right end of a ceiling frame (40 foot collapsible cargo container).

[29] FIG. 23A ("Drawings" page 20) shows a front view of the right end of a ceiling frame (40 foot collapsible cargo container).

[30] FIG. 24A ("Drawings" page 20) shows a right view of a ceiling frame (40 foot collapsible cargo container).

[31] FIG. 25A ("Drawings" page 21) shows isometric views of a left frame (40 foot collapsible cargo container).

[32] FIG. 26A ("Drawings" page 22) shows an Isometric internal view of the corner of a left frame (40 foot collapsible cargo container).

[33] FIG. 27A ("Drawings" page 23) shows an internal view of a left frame (40 foot collapsible cargo container).

[34] FIG. 28A ("Drawings" page 24) shows an external view of a left frame (40 foot collapsible cargo container).

[35] FIG. 29A ("Drawings" page 25) shows isometric views of a right frame (40 foot collapsible cargo container).

[36] FIG. 30A ("Drawings" page 26) shows an isometric internal view of the corner of a right frame (40 foot collapsible cargo container).

[37] FIG. 31A ("Drawings" page 27) shows an internal view of a right frame (40 foot collapsible cargo container).

[38] FIG. 32A ("Drawings" page 28) shows an external view of a right frame (40 foot collapsible cargo container).

[39] FIG. 33A/B ("Drawings" page 29) shows an isometric view of the front/back frame (40 foot and 40 foot high cube cargo containers).

[40] FIG. 34A/B ("Drawings" page 30) shows an isometric view of the top corner of a front/back frame (40 foot and 40 foot high cube cargo containers).

[41] FIG. 35A ("Drawings" page 31) shows an isometric view of a floor frame that contains a front frame and a back frame (40 foot collapsible cargo container).

[42] FIG. 36A ("Drawings" page 32) shows an isometric view of a ceiling frame stacked on top of a floor frame that contains a front frame and a back frame (40 foot collapsible cargo container), which is referred as "collapsible cargo container frame panel assembly".

[43] FIG. 37 ("Drawings" page 33) shows an isometric view of the base part, which is used to prevent the direct contact between "collapsible cargo container frame panel assembly" and "shipping floor frame panel", which is defined in FIG. 39A/C/D and FIG. 39B.

[44] FIG. 38 ("Drawings" page 34) shows an enlarged front view of a loaded collapsible cargo container that is also referred as shipping container. The shaded lines indicate the base part. The base parts are placed on top of the shipping container's floor frame base at both ends to support the disassembled frame panels

[45] FIG. 39A/C/D ("Drawings" page 35) shows a 40 foot shipping collapsible cargo container floor frame panel referred as "shipping floor frame panel", related front and back frame panels are stored in "shipping floor frame panel", a base part is placed on each end of "shipping floor frame panel".

[46] FIG. 39A/C/D, FIG. 40A/C/D, FIG. 41A - FIG. 48A are views, which, step by step, illustrate how to disassemble 40 foot collapsible cargo containers and how to load disassembled frame panels into a 40 foot collapsible cargo container for shipping.

[47] FIG. 1B ("Drawings" page 45) shows a basic isometric view of the 40 foot high cube collapsible cargo container loaded with two disassembled 40 foot high cube collapsible cargo container frames.

[48] FIG. 2B ("Drawings" page 46) shows a detailed isometric view of the 40 foot high cube collapsible cargo container loaded with two disassembled 40 foot high cube collapsible cargo container frames.

[49] FIG. 3B ("Drawings" page 47) shows a basic isometric view of the 40 foot high cube collapsible cargo container frame.

[50] FIG. 4B ("Drawings" page 48) shows an enlarged isometric view of the left end of a 40 foot high cube collapsible cargo container.

[51] FIG. 5B ("Drawings" page 49) shows an opaque isometric view of the 40 foot high cube collapsible cargo container frames.

[52] FIG. 6B ("Drawings" page 50) shows a basic isometric view of the floor frame (40 foot high cube collapsible cargo container).

[53] FIG. 7B ("Drawings" page 51) shows an opaque isometric view of the floor frame (40 foot high cube collapsible cargo container).

[54] FIG. 8B ("Drawings" page 52) shows an isometric view of the left end of the floor frame (40 foot high cube collapsible cargo container).

[55] FIG. 9B ("Drawings" page 53) shows a top view of the left end of a floor frame (40 foot high cube collapsible cargo container).

[56] FIG. 10B ("Drawings" page 54) shows a front view of the left end of a floor frame (40 foot high cube collapsible cargo container).

[57] FIG. 11B ("Drawings" page 54) shows a left view of a floor frame (40 foot high cube collapsible cargo container).

[58] FIG. 12B ("Drawings" page 55) shows an isometric view of the right end of a floor frame (40 foot high cube collapsible cargo container).

[59] FIG. 13B ("Drawings" page 56) shows a top view of the right end of a floor frame (40 foot high cube collapsible cargo container).

[60] FIG. 14B ("Drawings" page 57) shows a front view of the right end of a floor frame (40 foot high cube collapsible cargo container).

[61] FIG. 15B ("Drawings" page 57) shows a right view of a floor frame (40 foot high cube collapsible cargo container).

[62] FIG. 16B ("Drawings" page 58) shows an isometric view of a ceiling frame (40 foot high cube collapsible cargo container).

[63] FIG. 17B ("Drawings" page 59) shows an isometric view of the left end of a ceiling frame (40 foot high cube collapsible cargo container).

[64] FIG. 18B ("Drawings" page 60) shows a top view of the left end of a ceiling frame (40 foot high cube collapsible cargo container).

[65] FIG. 19B ("Drawings" page 61) shows a front view of the left end of a ceiling frame (40 foot high cube collapsible cargo container).

[66] FIG. 20B ("Drawings" page 61) shows a left view of a ceiling frame (40 foot high cube collapsible cargo container).

[67] FIG. 21B ("Drawings" page 62) shows an isometric view of the right end of a ceiling frame (40 foot high cube collapsible cargo container).

[68] FIG. 22B ("Drawings" page 63) shows a top view of the right end of a ceiling frame (40 foot high cube collapsible cargo container).

[69] FIG. 23B ("Drawings" page 64) shows a front view of the right end of a ceiling frame (40 foot high cube collapsible cargo container).

[70] FIG. 24B ("Drawings" page 64) shows a right view of a ceiling frame (40 foot high cube collapsible cargo container).

[71] FIG. 25B ("Drawings" page 65) shows isometric views of a left frame (40 foot high cube collapsible cargo container).

[72] FIG. 26B ("Drawings" page 66) shows an Isometric internal view of the corner of a left frame (40 foot high cube collapsible cargo container).

[73] FIG. 27B ("Drawings" page 67) shows an internal view of a left frame (40 foot high cube collapsible cargo container).

[74] FIG. 28B ("Drawings" page 68) shows an external view of a left frame (40 foot high cube collapsible cargo container).

[75] FIG. 29B ("Drawings" page 69) shows isometric views of a right frame (40 foot high cube collapsible cargo container).

[76] FIG. 30B ("Drawings" page 70) shows an isometric internal view of the corner of a right frame (40 foot high cube collapsible cargo container).

[77] FIG. 31B ("Drawings" page 71) shows an internal view of a right frame (40 foot high cube collapsible cargo container).

[78] FIG. 32B ("Drawings" page 72) shows an external view of a right frame (40 foot high cube collapsible cargo container).

[79] FIG. 35B ("Drawings" page 73) shows an isometric view of a floor frame that contains a front frame and a back frame (40 foot high cube collapsible cargo container).

[80] FIG. 36B ("Drawings" page 74) shows an isometric view of a ceiling frame stacked on top of a floor frame that contains a front frame and a back frame (40 foot high cube collapsible cargo container), which is referred as "collapsible cargo container frame panel assembly".

[81] FIG. 39B ("Drawings" page 75) shows a 40 foot high cube shipping collapsible cargo container floor frame panel referred as "shipping floor frame panel", related front and back frame panels are stored in "shipping floor frame panel", a base part is placed on each end of "shipping floor frame panel".

[82] FIG. 39B - FIG. 47B are views, which, step by step, illustrate how to disassemble 40 foot high cube collapsible cargo containers and how to load disassembled frame panels into a 40 foot high cube collapsible cargo container for shipping.

[83] FIG. 1C ("Drawings" page 84) shows a basic isometric view of the 40 foot collapsible cargo container loaded with six disassembled 20 foot collapsible cargo container frames.

[84] FIG. 2C ("Drawings" page 85) shows a detailed isometric view of the 40 foot collapsible cargo container loaded with six disassembled 20 foot collapsible cargo container frames.

[85] FIG. 3C ("Drawings" page 86) shows a basic isometric view of the 20 foot collapsible cargo container frame.

[86] FIG. 4C ("Drawings" page 87) shows an enlarged isometric view of the left end of a 20 foot collapsible cargo container.

[87] FIG. 6C ("Drawings" page 88) shows a basic isometric view of the floor frame (20 foot collapsible cargo container).

[88] FIG. 12C ("Drawings" page 89) shows an isometric view of the right end of a floor frame (20 foot collapsible cargo container).

[89] FIG. 13C ("Drawings" page 90) shows a top view of the right end of a floor frame (20 foot collapsible cargo container).

[90] FIG. 14C ("Drawings" page 91) shows a front view of the right end of a floor frame (20 foot collapsible cargo container).

[91] FIG. 15C ("Drawings" page 91) shows a right view of a floor frame (20 foot collapsible cargo container).

[92] FIG. 16C ("Drawings" page 92) shows an isometric view of a ceiling frame (20 foot collapsible cargo container).

[93] FIG. 21C ("Drawings" page 93) shows an isometric view of the right end of a ceiling frame (20 foot collapsible cargo container).

[94] FIG. 22C ("Drawings" page 94) shows a top view of the right end of a ceiling frame (20 foot collapsible cargo container).

[95] FIG. 23C ("Drawings" page 95) shows a front view of the right end of a ceiling frame (20 foot collapsible cargo container).

[96] FIG. 24C ("Drawings" page 95) shows a right view of a ceiling frame (20 foot collapsible cargo container).

[97] FIG. 25C ("Drawings" page 96) shows isometric views of a left frame (20 foot collapsible cargo container).

[98] FIG. 26C ("Drawings" page 97) shows an Isometric internal view of the corner of a left frame (20 foot collapsible cargo container).

[99] FIG. 27C ("Drawings" page 98) shows an internal view of a left frame (20 foot collapsible cargo container).

[100] FIG. 28C ("Drawings" page 99) shows an external view of a left frame (20 foot collapsible cargo container).

[101] FIG. 29C ("Drawings" page 100) shows isometric views of a right frame (20 foot collapsible cargo container).

[102] FIG. 30C ("Drawings" page 101) shows an isometric internal view of the corner of a right frame (20 foot collapsible cargo container).

[103] FIG. 31C ("Drawings" page 102) shows an internal view of a right frame (20 foot collapsible cargo container).

[104] FIG. 32C ("Drawings" page 103) shows an external view of a right frame (20 foot collapsible cargo container).

[105] FIG. 33C/D ("Drawings" page 104) shows an isometric view of the front/back frame (20 foot and 20 foot high cube cargo containers).

[106] FIG. 34C/D ("Drawings" page 105) shows an isometric view of the top corner of a front/back frame (20 foot and 20 foot high cube cargo containers).

[107] FIG. 35C ("Drawings" page 106) shows an Isometric view of connected floor frame that contains two front frames and two back frames (20 foot collapsible cargo container).

[108] FIG. 36C ("Drawings" page 107) shows an Isometric view of connected ceiling frames stacked on top of connected floor frames. Each connected floor frame contains two front frames and two back frames (20 foot collapsible cargo container). This assembly is referred as "collapsible cargo container frame panel assembly".

[109] FIG. 39 A/C/D, FIG. 40A/C/D, FIG. 41C – FIG. 48C are views, which, step by step, illustrate how to disassemble 20 foot collapsible cargo containers and how to load disassembled frame panels into a 40 foot collapsible cargo container for shipping.

[110] FIG. 49C ("Drawings" page 116) shows that two connectors connect two ceiling frame panels during the shipping process (20 foot collapsible cargo container).

[111] FIG. 50C ("Drawings" page 117) shows a detail view based on FIG. 49C.

[112] FIG. 51C ("Drawings" page 118) shows that two connectors connect two floor frame panels during the shipping process (20 foot collapsible cargo container).

[113] FIG. 52C ("Drawings" page 119) shows a detail view based on FIG. 51C.

[114] FIG. 53C ("Drawings" page 120) shows two connectors used to connect two floor frame panels as well as two ceiling frame panels (20 foot collapsible cargo container).

[115] FIG. 1D ("Drawings" page 121) shows a basic isometric view of the 40 foot collapsible cargo container loaded with four disassembled 20 foot high cube collapsible cargo container frames.

[116] FIG. 2D ("Drawings" page 122) shows a detailed isometric view of the 40 foot collapsible cargo container loaded with four disassembled 20 foot high cube collapsible cargo container frames.

[117] FIG. 3D ("Drawings" page 123) shows a basic isometric view of the 20 foot high cube collapsible cargo container frame.

[118] FIG. 4D ("Drawings" page 124) shows an enlarged isometric view of the left end of a 20 foot high cube collapsible cargo container.

[119] FIG. 6D ("Drawings" page 125) shows a basic isometric view of the floor frame (20 foot high cube collapsible cargo container).

[120] FIG. 12D ("Drawings" page 126) shows an isometric view of the right end of a floor frame (20 foot high cube collapsible cargo container).

[121] FIG. 13D ("Drawings" page 127) shows a top view of the right end of a floor frame (20 foot high cube collapsible cargo container).

[122] FIG. 14D ("Drawings" page 128) shows a front view of the right end of a floor frame (20 foot high cube collapsible cargo container).

[123] FIG. 15D ("Drawings" page 128) shows a right view of a floor frame (20 foot high cube collapsible cargo container).

[124] FIG. 16D ("Drawings" page 129) shows an isometric view of a ceiling frame (20 foot high cube collapsible cargo container).

[125] FIG. 21D ("Drawings" page 130) shows an isometric view of the right end of a ceiling frame (20 foot high cube collapsible cargo container).

[126] FIG. 22D ("Drawings" page 131) shows a top view of the right end of a ceiling frame (20 foot high cube collapsible cargo container).

[127] FIG. 23D ("Drawings" page 132) shows a front view of the right end of a ceiling frame (20 foot high cube collapsible cargo container).

[128] FIG. 24D ("Drawings" page 132) shows a right view of a ceiling frame (20 foot high cube collapsible cargo container).

[129] FIG. 25D ("Drawings" page 133) shows isometric views of a left frame (20 foot high cube collapsible cargo container).

[130] FIG. 26D ("Drawings" page 134) shows an Isometric internal view of the corner of a left frame (20 foot high cube collapsible cargo container).

[131] FIG. 27D ("Drawings" page 135) shows an internal view of a left frame (20 foot high cube collapsible cargo container).

[132] FIG. 28D ("Drawings" page 136) shows an external view of a left frame (20 foot high cube collapsible cargo container).

[133] FIG. 29D ("Drawings" page 137) shows isometric views of a right frame (20 foot high cube collapsible cargo container).

[134] FIG. 30D ("Drawings" page 138) shows an isometric internal view of the corner of a right frame (20 foot high cube collapsible cargo container).

[135] FIG. 31D ("Drawings" page 139) shows an internal view of a right frame (20 foot high cube collapsible cargo container).

[136] FIG. 32D ("Drawings" page 140) shows an external view of a right frame (20 foot high cube collapsible cargo container).

[137] FIG. 35D ("Drawings" page 141) shows an Isometric view of connected floor frame that contains two front frames and two back frames (20 foot high cube collapsible cargo container).

[138] FIG. 36D ("Drawings" page 142) shows an Isometric view of connected ceiling frames stacked on top of connected floor frames. Each connected floor frame contains two front frames and two back frames (20 foot high cube collapsible cargo container). This assembly is referred as "collapsible cargo container frame panel assembly"

[139] FIG. 39 A/C/D, FIG. 40A/C/D, FIG. 41D – FIG. 47D are views, which, step by step, illustrate how to disassemble 20 foot high cube collapsible cargo containers and how to load disassembled frame panels into a 40 foot collapsible cargo container for shipping.

[140] FIG. 49D ("Drawings" page 150) shows that two connectors connect two ceiling frame panels during the shipping process (20 foot high cube collapsible cargo container)

[141] FIG. 50D ("Drawings" page 151) shows a detail view based on FIG. 49D.

[142] FIG. 51D ("Drawings" page 152) shows that two connectors connect two floor frame panels during the shipping process (20 foot high cube collapsible cargo container).

[143] FIG. 52D ("Drawings" page 153) shows a detail view based on FIG. 51D.

[144] FIG. 53D ("Drawings" page 154) shows two connectors used to connect two floor frame panels as well as two ceiling frame panels (20 foot high cube collapsible cargo container).

[145] FIG. 54 ("Drawings" page 155) is the female pin base that is part of the floor/ceiling frame panel; it is used to connect with the male pin base that is part of the front/back frame panel.

[146] FIG. 55 ("Drawings" page 155) is the male pin base; it locks the front/back frame panel and the floor/ceiling frame panel together.

[147] FIG. 56 ("Drawings" page 155) is the joint T pin holder that is part of the right/left frame panel; it is used to connect with the joint T pin that is part of the floor/ceiling frame panel.

[148] FIG. 57 ("Drawings" page 155) is the joint T pin; it locks the floor/ceiling frame panel and the right/left frame panel together.

[149] FIG. 58A/B ("Drawings" page 156) shows the frame panel structure model (40 foot collapsible cargo container).

[150] FIG. 59 ("Drawings" page 156) shows those I-Beams, [-Beams and []-Beams used to construct the collapsible cargo container frame panel structure.

[151] FIG. 60A/B ("Drawings" page 156) shows the front/back frame panel structure model (40 foot collapsible cargo container).

[152] FIG. 61A/B ("Drawings" page 157) shows the modified front/back frame panel structure model consisted of only three vertical columns (40 foot collapsible cargo container).

[153] FIG. 62 ("Drawings" page 157) shows the collapsible cargo container left frame vertical column section view.

[154] FIG. 63 ("Drawings" page 157) shows the collapsible cargo container right frame vertical column section view.

[155] FIG. 64A/B ("Drawings" page 158) shows the floor frame panel structure model (40 foot collapsible cargo container).

[156] FIG. 65A/B ("Drawings" page 158) shows the ceiling frame panel structure model (40 foot collapsible cargo container).

[157] FIG. 66A/B ("Drawings" page 158) shows the frame panel structure load conditions (40 foot collapsible cargo container).

[158] FIG. 67A/B ("Drawings" page 159) shows the frame panel under the centralized load at the four floor longitude beam corners as well as its weight load (40 foot collapsible cargo container).

[159] FIG. 68A ("Drawings" page 159) shows the frame panel structure deformation graph under 44,452kg distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four floor corners).

[160] FIG. 69A ("Drawings" page 160) shows the frame panel structure deformation graph under 29,871 distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four floor corners).

[161] FIG. 70A ("Drawings" page 160) shows the frame panel structure deformation graph under 22,221kg load at the four floor corners and 3,088 kg weight load (40 foot collapsible cargo container simply supported at the four floor corners).

[162] FIG. 71A ("Drawings" page 161) shows the frame panel structure deformation graph under 44,452kg distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four ceiling corners).

[163] FIG. 72A ("Drawings" page 161) shows the frame panel structure deformation graph under 29,871 distributed load and 3,088 kg weight (40 foot collapsible cargo container simply supported at the four ceiling corners).

[164] FIG. 73A ("Drawings" page 162) shows the frame panel structure deformation graph under 22,221kg load at the four floor corners and 3,088 kg weight load (40 foot collapsible cargo container simply supported at the four ceiling corners).

[165] FIG. 68B ("Drawings" page 162) shows the frame deformation graph under 44,452kg distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four floor corners).

[166] FIG. 69B ("Drawings" page 163) shows the frame deformation graph under 29,871 distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four floor corners).

[167] FIG. 70B ("Drawings" page 163) shows the frame deformation graph under 22,221kg load at the four floor corners and 3,117 kg weight load (40 foot high cube collapsible container simply supported at the four floor corners).

[168] FIG. 71B ("Drawings" page 164) shows the frame deformation graph under 44,452kg distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four top corners).

[169] FIG. 72B ("Drawings" page 164) shows the frame deformation graph under 29,871kg distributed load and 3,117 kg weight (40 foot high cube collapsible container simply supported at the four top corners).

[170] FIG. 73B ("Drawings" page 165) shows the frame deformation graph under 22,221kg load at the four floor corners and 3,117 kg weight load (40 foot high cube collapsible container simply supported at the four top corners).

[171] FIG. 58C/D ("Drawings" page 165) shows the frame panel structure model (20 foot collapsible cargo container).

[172] FIG. 60C/D ("Drawings" page 166) shows the front/back frame panel structure model (20 foot collapsible cargo container).

[173] FIG. 61C/D ("Drawings" page 166) shows the modified front/back frame consisted only by one vertical column (20 foot collapsible cargo container).

[174] FIG. 64C/D ("Drawings" page 166) shows the floor frame panel structure model (20 foot collapsible cargo container).

[175] FIG. 65C/D ("Drawings" page 167) shows the ceiling frame panel structure model (20 foot collapsible cargo container).

[176] FIG. 66C/D ("Drawings" page 167) shows the distributed load and weight load (20 foot collapsible cargo container).

[177] FIG. 67C/D ("Drawings" page 168) shows the frame under a centralized load at the four floor beam corners as well as its weight load (20 foot collapsible cargo container).

[178] FIG. 68C ("Drawings" page 168) shows the frame deformation graph under 44,452kg distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four floor corners).

[179] FIG. 69C ("Drawings" page 169) shows the frame deformation graph under 29,871kg distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four floor corners).

[180] FIG. 70C ("Drawings" page 169) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1891kg weight load (20 foot collapsible cargo container simply supported at the four floor corners).

[181] FIG. 71C ("Drawings" page 170) shows the frame deformation graph under 44,452kg distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four top corners).

[182] FIG. 72C ("Drawings" page 170) shows the frame deformation graph under 29,871 distributed load and 1891kg weight (20 foot collapsible cargo container simply supported at the four top corners).

[183] FIG. 73C ("Drawings" page 171) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1891kg weight load (20 foot collapsible cargo container simply supported at the four top corners).

[184] FIG. 68D ("Drawings" page 171) shows the frame deformation graph under 44,452kg distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four floor corners).

[185] FIG. 69D ("Drawings" page 172) shows the frame deformation graph under 29,871 distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four floor corners).

[186] FIG. 70D ("Drawings" page 172) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1936kg weight load (20 foot high cube collapsible container simply supported at the four floor corners).

[187] FIG. 71D ("Drawings" page 173) shows the frame deformation graph under 44,452kg distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four top corners).

[188] FIG. 72D ("Drawings" page 173) shows the frame deformation graph under 29,871kg distributed load and 1936kg weight (20 foot high cube collapsible container simply supported at the four top corners).

[189] FIG. 73D ("Drawings" page 174) shows the frame deformation graph under 22,221kg load at the four floor beam corners and 1936kg weight load (20 foot high cube collapsible container simply supported at the four top corners).

[190] FIG. 74 ("Drawings" page 174) shows the joint T pin holder and its load condition.

[191] FIG. 75 ("Drawings" page 175) shows the floor level joint T pin holder stress contour graph.

[192] FIG. 76 (“Drawings” page 175) shows the ceiling level joint T pin holder stress contour graph.

[193] FIG. 77 (“Drawings” page 176) shows the joint T pin holder detail analysis.

[194] FIG. 78 (“Drawings” page 177) shows the joint T pin holder detail stress contour graph at the floor level.

[195] FIG. 79 (“Drawings” page 177) shows the joint T pin holder detail stress contour graph at the ceiling level.

[196] FIG. 80 (“Drawings” page 178) shows the male pin base.

[197] FIG. 81 (“Drawings” page 178) shows the male pin base finite element model and load.

[198] FIG. 82 (“Drawings” page 179) shows the male pin base stress contour graph.

[199] FIG. 83 (“Drawings” page 179) shows the male pin base deformation graph of X-orientation.

[200] FIG. 84 (“Drawings” page 180) shows the male pin base deformation graph of Y-orientation.

[201] FIG. 85 (“Drawings” page 180) shows the female pin base.

[202] FIG. 86 (“Drawings” page 181) shows the female pin base finite element model and load.

[203] FIG. 87 (“Drawings” page 181) shows the female pin base stress contour graph.

[204] FIG. 88 (“Drawings” page 182) shows the female pin base deformation graph of X-orientation.

[205] FIG. 89 (“Drawings” page 182) shows the female pin base deformation graph of Y-orientation.

[206] Table 1A (“Drawings” page 183) shows the inner force of the cross beams in the front/back frame panel structure as shown in FIG. 60A/B (40 foot collapsible cargo container).

[207] Table 1B (“Drawings” page 183) shows the inner forces of the cross beams in the front/back frame panel structure as shown in FIG. 60A/B (40 foot high cube collapsible cargo container).

[208] Table 1C (“Drawings” page 184) shows the inner forces of the cross beams in the front/back frame panel structure as shown in FIG. 60C/D (20 foot collapsible cargo container).

[209] Table 1D ("Drawings" page 184) shows the inner forces of the cross beams in the front/back frame panel structure as shown in FIG. 60C/D (20 foot high cube collapsible cargo container).

[210] Table 2A ("Drawings" page 184) shows the inner forces of the vertical beams as shown in FIG. 61A/B (40 foot collapsible cargo container).

[211] Table 2B ("Drawings" page 185) shows the inner forces of the vertical beams as shown in FIG. 61A/B (40 foot high cube collapsible cargo container).

[212] Table 2C ("Drawings" page 185) shows the inner forces of the vertical beams as shown in FIG. 61C/D (20 foot collapsible cargo container).

[213] Table 2D ("Drawings" page 185) shows the inner forces of the vertical beams as shown in FIG. 61C/D (20 foot high cube collapsible cargo container).

DETAILED DESCRIPTION OF THE INVENTION

1. The collapsible cargo container

[214] The collapsible cargo container consists of six-component frame panels:

- Floor frame panel as shown in FIG. 6A, FIG. 6B, FIG. 6C and FIG. 6D.
- Ceiling frame panel as shown in FIG. 16A, FIG. 16B, FIG. 16C and FIG. 16D.
- Left frame panel as shown in FIG. 25A, FIG. 25B, FIG. 25C and FIG. 25D.
- Right frame panel as shown in FIG. 29A, FIG. 29B, FIG. 29C and FIG. 29D.
- Front panel as shown in FIG. 33A/B and FIG. 33C/D.
- Back panel as shown in FIG. 33A/B and FIG. 33C/D.

Each of the six component frame panels is composed of steel beams. Additionally, there are two steel columns in the right and left frame panels, and a steel plate in the 40 foot cargo container floor frame panel. The characteristics of the steel beam, steel column and steel plate are described in detail in the next section titled 'The collapsible cargo container frame panel structure analysis'.

[215] The six component frame panels of the collapsible cargo container are assembled together through their connectors:

The female pin base connector as shown in FIG. 54

The male pin base connector as shown in FIG. 55

The joint T pin holder as shown in FIG. 56

- The joint T pin as shown in FIG. 57

The female pin base connector and male pin base connector are used to assemble the floor frame panel, the front/back frame panels, and the ceiling frame panel together. The joint T pin holder and joint T pin are used to assemble the right/left frame panels and the floor/ceiling frame panels together.

[216] For the 40 foot collapsible cargo container, 10 female pin base connectors are attached to the floor frame panel as shown in FIG. 6A, FIG. 8A and FIG. 12A. 10 female pin base connectors are attached to the ceiling frame panel as shown in FIG. 16A, FIG. 17A and FIG. 21A. 10 male pin base connectors are attached to the front frame panel as shown in FIG. 33A/B and FIG. 34A/B. 10 male pin base connectors are attached to the back frame panel as shown in FIG. 33A/B and FIG. 34A/B. 8 joint T pin holders are attached to the left frame panels as shown in FIG. 25A and FIG. 26A. 8 joint T pin holders are attached to the right frame panels as shown in FIG. 29A and FIG. 30A. There are 4 joint T pins on each side of the floor frame panel as shown in FIG. 6A, FIG. 8A and FIG. 12A. There are 4 joint T pins on each side of the ceiling frame panel as shown in FIG. 16A, FIG. 17A and FIG. 21A. The complete 40 foot collapsible cargo container assembly is shown in FIG. 3A.

[217] For the 40 foot high cube collapsible cargo container, 10 female pin base connectors are attached to the floor frame panel as shown in FIG. 6B, FIG. 8B and FIG. 12B. 10 female pin base connectors are attached to the ceiling frame panel as shown in FIG. 16B, FIG. 17 B and FIG. 21B. 10 male pin base connectors are attached to the front frame panel as shown in FIG. 33A/B and FIG. 34A/B. 10 male pin base connectors are attached to the back frame panel as shown in FIG. 33A/B and FIG. 34A/B. 8 joint T pin holders are attached to the left frame panels as shown in FIG. 25B and FIG. 26B. 8 joint T pin holders are attached to the right frame panels as shown in FIG. 29B and FIG. 30B. There are 4 joint T pins on each side of the floor frame panel as shown in FIG. 6B, FIG. 8B and FIG. 12B. There are 4 joint T pins on each side of the ceiling frame panel

as shown in FIG. 16B, FIG. 17B and FIG. 21B. The complete 40 foot high cube collapsible cargo container assembly is shown in FIG. 3B.

[218] For the 20 foot collapsible cargo container, 6 female pin base connectors are attached to the floor frame panel as shown in FIG. 6C, and FIG. 12C. 6 female pin base connectors are attached to the ceiling frame panel as shown in FIG. 16C, and FIG. 21C. 6 male pin base connectors are attached to the front frame panel as shown in FIG. 33C/D and FIG. 34C/D. 6 male pin base connectors are attached to the back frame panel as shown in FIG. 33C/D and FIG. 34C/D. 8 joint T pin holders are attached to the left frame panels as shown in FIG. 25C and FIG. 26C. 8 joint T pin holders are attached to the right frame panels as shown in FIG. 29C and FIG. 30C. There are 4 joint T pins on each side of the floor frame panel as shown in FIG. 6C, FIG. 12C. There are 4 joint T pins on each side of the ceiling frame panel as shown in FIG. 16C, and FIG. 21C. The complete 20 foot collapsible cargo container assembly is shown in FIG. 3C.

[219] For the 20 foot high cube collapsible cargo container, 6 female pin base connectors are attached to the floor frame panel as shown in FIG. 6D, and FIG. 12D. 6 female pin base connectors are attached to the ceiling frame panel as shown in FIG. 16D, and FIG. 21D. 6 male pin base connectors are attached to the front frame panel as shown in FIG. 33C/D and FIG. 34C/D. 6 male pin base connectors are attached to the back frame panel as shown in FIG. 33C/D and FIG. 34C/D. 8 joint T pin holders are attached to the left frame panels as shown in FIG. 25D and FIG. 26D. 8 joint T pin holders are attached to the right frame panels as shown in FIG. 29D and FIG. 30D. There are 4 joint T pins on each side of the floor frame panel as shown in FIG. 6D, and FIG. 12D. There are 4 joint T pins on each side of the ceiling frame panel as shown in FIG. 16D, and FIG. 21D. The complete 20 foot high cube collapsible cargo container assembly is shown in FIG. 3D.

[220] During empty cargo container repositioning, an empty collapsible cargo container is disassembled into six component frame panels; those component frame panels are loaded into "shipping collapsible cargo container" (show in FIG. 1A, FIG. 1B, FIG. 1C and FIG. 1D), "shipping collapsible cargo container" is then shipped to its destination. After "shipping collapsible cargo container" arrives at its destination, the disassembled

component frame panels will remain in "shipping collapsible cargo container" until needed.

[221] By contacting base parts only (show in FIG. 37 and FIG. 38), "collapsible cargo container frame panel assembly" (show in FIG. 36A, FIG. 36B, FIG. 36C and FIG 36D) displaces its carried load at four corner points of "shipping floor frame panel" (show in FIG. 39A/C/D and FIG. 39B), which reduces said load impact on said "shipping floor frame panel" to the minimal.

[222] Through connectors (show in FIG. 53C and FIG. 53D), connect two 20-foot floor/ceiling frame panels into a 40 foot equivalent frame panel (show in FIG. 49C, FIG. 49D, FIG. 51C and FIG. 51D), which keeps load impact created by disassembled 20 foot collapsible cargo container frame panels behavior same as disassembled 40 foot ones.

[223] A special lifting device that is capable of holding and lifting the collapsible cargo container frame panels will be used during the disassembling process of the collapsible cargo container. 40 foot collapsible cargo containers are disassembled and loaded into a 40 foot collapsible cargo container as shown in FIG. 1A. 40 foot high cube collapsible cargo containers are disassembled and loaded into a 40 foot high cube collapsible cargo container as shown in FIG. 1B. 20 foot collapsible cargo containers are disassembled and loaded into a 40 foot collapsible cargo container as shown in FIG. 1C. 20 foot high cube collapsible cargo containers are disassembled and loaded into a 40 foot collapsible cargo container as shown in FIG. 1D.

[224] FIG. 39A/C/D, FIG. 41A - FIG. 48A show the detailed step-by-step procedure to load disassembled 40 foot collapsible cargo container component frame panels into 40 foot collapsible cargo containers.

[225] FIG. 39B, FIG. 41B - FIG. 47B show the detailed step-by-step procedure to load disassembled 40 foot high cube collapsible cargo container component frame panels into 40 foot high cube collapsible cargo containers.

[226] FIG. 39A/C/D, FIG. 41C - FIG. 48C show the detailed step-by-step procedure to load disassembled 20 foot collapsible cargo container component frame panels into 40 foot collapsible cargo containers. FIG. 49C and FIG. 50C show two 20 foot ceiling frame panels connected into a 40 foot equivalent ceiling frame panel through the connector as shown in FIG. 53C. FIG. 51C and FIG. 52C show two 20 foot floor frame panels

connected into a 40 foot equivalent floor frame panel through the connector as shown in FIG 53C.

[227] FIG. 39A/C/D, FIG. 41D - FIG. 47D show the detailed step-by-step procedure to load disassembled 20 foot high cube collapsible cargo container component frame panels into 40 foot collapsible cargo containers. FIG. 49D and FIG. 50D show two 20 foot high cube ceiling frame panels connected into a 40 foot equivalent ceiling frame panel through the connector as shown in FIG. 53D. FIG. 51D and FIG. 52D show two 20 foot high cube floor frame panels connected into a 40 foot equivalent floor frame panel through the connector as shown in FIG 53D.

[228] Compared to the traditional cargo container, the collapsible cargo container has a new unique feature, i.e. it can be shipped as cargo, thereby significantly reducing the empty cargo container repositioning cost. It will also significantly reduce the space demand in container yards due to the fact that the disassembled collapsible cargo containers will remain in "shipping collapsible cargo container" until needed.

2. The collapsible cargo container frame panel structure analysis

2.1 Overview

[229] JIFEX developed by Dalian University of Technology, is software providing the analysis and optimization of general finite elements, which is similar to ANSYS and NASTRAN. Dr. Guozhong Zhao, a Ph.D. in Engineering Mechanics, has used JIFEX to conduct the collapsible cargo container frame panel structure analysis, provided the structure analysis datum result including deformation and stress graphs. The analysis datum inidcate the collapsible cargo container frame panel is very rigid and sound structure.

2.2 The collapsible cargo container structural model

[230] The 40 foot cargo container frame panel structure is modeled as shown in FIG. 58A/B. Its sizes are defined as follows:

L = 40 feet, L` = 2.5 feet, H = 8 feet 6 inches, W = 8 feet, W2 = 41 inches, W1 = W3 = 27.5 inches.

[231] The 40 foot high cube cargo container frame panel structure is modeled as shown in FIG. 58A/B. Its sizes are defined as the followings:

L = 40 feet, L`= 2.5 feet, H = 9.5 feet, W = 8 feet, W2 = 41 inches, W1 = W3 = 27.5 inches.

[232] The 20 foot cargo container frame panel structure is modeled as shown in FIG. 58C/D. Its sizes are defined as the followings:

L = 20 feet, L`= 1.25 feet, L`` = 2.5 feet, H = 8.5feet, W = 8 feet

[233] The 20 foot high cube cargo container frame panel structure is modeled as shown in FIG. 58C/D. Its sizes are defined as the followings:

L = 20 feet, L`= 1.25 feet, L`` = 2.5 feet, H = 9.5feet, W = 8 feet

2.3 The material property

[234] Material: Steel

Young's module: $E = 212Gp = 212\times10^{9} N/m^{2} = 212\times10^{7} kg/(s^{2}cm)$

Density: $\rho = 7860kg/m^{3} = 0.007860kg/cm^{3}$

$\mu = 0.288$

$\sigma_s = 235Mp$

τ_p=140MP

2.4 The I-Beam, [-Beam and []-Beam

[235] The collapsible cargo container frame panel structure consists of I-beams, [-beams and []-beams as shown in FIG. 59.

The I-Beam is available in the following sizes:

- I-Beam(1): H=10cm, W=6.8cm, Th=0.76cm, Tw=0.45cm
- I-Beam(2): H=12.6cm, W=7.4cm, Th=0.84cm, Tw=0.5cm

The [-Beam is available in the following sizes:

- [-Beam(1): H=6.3cm, W=4cm, Th=0.75cm, Tw=0.48cm

The []-Beam is available in the following sizes:

[]-Beam(1): H=3cm, W=3cm, T=0.4cm

[]-Beam(2): H=18cm, W=10cm, T=0.8cm

- []-Beam(3): H=20cm, W=10cm, T=0.8cm

2.5 The 40 foot collapsible cargo container frame panel structures

[236] Reference: FIG. 60A/B

[-Beam(1) is the cross beam specified in the labels 2, 3, 5, 6, 8, 9, 11 and 12. []-Beam(1) is the vertical beam specified in the labels 4, 7 and 10. Four [-Beams(1) specified in each of the labels 14 and 15 reinforce the stability of the surrounding [-Beams(1). The vertical columns labeled as 1 and 13 are specially manufactured. The specific size of these vertical columns is specified in FIG. 62 and FIG. 63.

[237] Reference: FIG. 64A/B

[]-Beam(3) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the transverse beams specified in the labels 3, 7, 11, 15, 18 and 19. I-Beam(1) is the transverse beams specified in the labels 4, 5, 6, 8, 9, 10, 12, 13 and 14. I-Beam(1) is the short transverse beams specified in the labels 16, 17, 20-25. The plate with its wall thickness equal to 0.3cm is labeled as 26.

[238] Reference: FIG. 65A/B

[]-Beam(2) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the edge transverse beams specified in the labels 3 and 7. [-Beam(1) is the edge transverse beams specified in the labels 4-6.

2.6 20 foot collapsible cargo container frame panel structure

[239] Reference: FIG. 60C/D

[-Beam(1) is the cross beam specified in the labels 2, 3, 5 and 6. []-Beam(1) is the vertical beam specified in the label 4. Four [-Beams(1) specified in each of the labels 8 and 9 reinforce the stability of the surrounding [-Beams(1). The vertical columns labeled as 1 and 7 are specially manufactured. The specific size of these vertical columns is specified in FIG. 62 and FIG. 63.

[240] Reference: FIG. 64C/D

[]-Beam(3) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the transverse beams specified in the labels 3, 9 and 15. I-Beam(1) is the transverse beams specified in the labels 4, 5, 6, 7, 8,10, 11, 12, 13 and 14.

[241] Reference: FIG. 65C/D

[]-Beam(2) is the longitudinal beam specified in the labels 1 and 2. I-Beam(2) is the edge transverse beams specified in the labels 3 and 5. [-Beam(1) is the edge transverse beams specified in the label 4.

2.7The numerical result

2.7.1 The 40 foot cargo container structure simply supported at the floor corners

[242] The first load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB - distributed load on the floor is shown in FIG. 66A/B,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$ where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without an open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB-centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the 40 foot cargo container frame panel structure is shown in FIG. 68A. The maximum displacement 1.6760cm is located in the floor. The maximum displacement in the floor longitudinal beams is 0.529cm.

[243] The second load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, where 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB-centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$
The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$
The deformation graph of the 40 foot cargo container frame panel structure is shown in FIG. 69A. The maximum displacement 1.1619cm is located in the floor. The maximum displacement in the floor longitudinal beams is 0.378cm.

[244] The third load condition for the modified 40 foot collapsible cargo container frame panel structure is defined as the followings:

As shown in FIG. 61A/B and FIG. 67A/B, the front and back frames of the 40 foot collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$
The deformation graph of the modified 40 foot cargo container frame panel structure is shown in FIG. 70A. The maximum displacement 1.1360cm is located in the floor. The maximum displacement in the floor longitudinal beams is also 1.1360cm.

2.7.2 The 40 foot cargo container structure simply supported at the ceiling corners

[245] The first load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in FIG. 66A/B,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$
The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the 40 foot cargo container frame panel structure is shown in FIG. 71A, the maximum displacement 1.6869cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.500cm.

[246] The second load condition for the 40 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, in which, 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the 40 foot cargo container frame panel structure is shown in FIG. 72A, the maximum displacement 1.1750cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.355cm.

[247] The third load condition for modified the 40 foot collapsible cargo container frame panel structure is defined as the followings:

As the FIG. 61A/B and FIG. 67A/B shown, the front and back frames of the 40 foot collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 6,947 LB or 3,088 kg,

$3088kg \times 9.80m/s^2 = 30262.4N = 3026240kg \cdot cm/s^2$

The deformation graph of the modified 40 foot cargo container frame panel structure is shown in FIG. 73A, the maximum displacement 1.1408cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 1.1408cm.

2.7.3 The 40 foot high cube cargo container structure simply supported at the floor

corners

[248] The first load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in FIG. 66A/B,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without an open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in FIG. 68B, the maximum displacement 1.7046cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.584cm.

[249] The second load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, where the 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in FIG. 69B, the maximum displacement 1.1823cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.414cm.

[250] The third load condition for the modified 40 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the FIG. 61A/B and FIG. 67A/B shown, the front and back frames of the 40 foot high cube collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.
The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the modified 40 foot high cube cargo container frame panel structure is shown in FIG. 70B, the maximum displacement 1.1501cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 1.1501cm.

2.7.4 The 40 foot high cube cargo container structure simply supported at the ceiling corners

[251] The first load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in FIG. 66A/B,

$100,000LB = 444520.16N = 44452016kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in FIG. 71B, the maximum displacement 1.7020cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.556cm.

[252] The second load condition for the 40 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66A/B,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, in which, 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the 40 foot high cube cargo container frame panel structure is shown in FIG. 72B, the maximum displacement 1.1841cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.392cm.

[253] The third load condition for the modified 40 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the FIG. 61A/B and FIG. 67A/B shown, the front and back frames of the 40 foot high cube collapsible cargo container frame panel structure have been replaced by six vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67A/B,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 7,012 LB or 3,117 kg,

$3117kg \times 9.80m/s^2 = 30546.6N = 3054660kg \cdot cm/s^2$

The deformation graph of the modified 40 foot high cube cargo container frame panel structure is shown in FIG. 73B, the maximum displacement 1.1558cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 1.1558cm.

2.7.5 The 20 foot cargo container structure simply supported at the four floor corners

[254] The first load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in FIG. 66C/D,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The first load deformation graph of the 20 foot cargo container frame panel structure is shown in FIG. 68C, the maximum displacement 1.5682cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.475cm.

[255] The second load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66C/D,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, where the 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The deformation graph of the 20 foot cargo container frame panel structure is shown in FIG. 69C, the maximum displacement 1.0703cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.331cm.

[256] The third load condition for the modified 20 foot collapsible cargo container frame panel structure is defined as the followings:

As the FIG. 61C/D and FIG. 67C/D shown, the front and back frames of the 20 foot collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The deformation graph of the modified 20 foot cargo container frame panel structure is shown in FIG. 70C, the maximum displacement 0.21378cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.21378.

2.7.6 The 20 foot cargo container structure simply supported at the ceiling corners

[257] The first load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in FIG. 66C/D,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$ □where 11/16 of the distributed load ($30560761kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($13891255kg \cdot cm/s^2$) is on the part of the floor with the open gap.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The deformation graph of the 20 foot cargo container frame panel structure is shown in FIG. 71C, the maximum displacement 1.5608cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.489cm.

[258] The second load condition for the 20 foot collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66C/D,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$, in which, 11/16 of the distributed load ($20536831.5625kg \cdot cm/s^2$) is on the part of the floor without the open gap, and 5/16 of the distributed load ($9334923.4375kg \cdot cm/s^2$) is on the part of the floor with the open.

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The deformation graph of the 20 foot cargo container frame panel structure is shown in FIG. 72C, the maximum displacement 1.0650cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.345cm.

[259] The third load condition for the modified 20 foot collapsible cargo container frame panel structure is defined as the followings:

As the FIG. 61C/D and FIG. 67C/D shown, the front and back frames of the 20 foot collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 4,254 LB or 1981 kg,

$1891kg \times 9.80m/s^2 = 18531.8N = 1853180kg \cdot cm/s^2$

The deformation graph of the modified 20 foot cargo container frame panel structure is shown in FIG. 73C, the maximum displacement 0.21922cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.21922cm.

2.7.7 The 20 foot high cube cargo container structure simply supported at the floor corners

[260] The first load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in FIG. 66C/D,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in FIG. 68D, the maximum displacement 1.5712cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.486cm.

[261] The second load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66C/D,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the ceiling end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in FIG. 69D, the maximum displacement 1.0735cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.339cm.

[262] The third load condition for the modified 20 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the FIG. 61C/D and FIG. 67C/D shown, the front and back frames of the 20 foot high cube collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the modified 20 foot high cube cargo container frame panel structure is shown in FIG. 70D, the maximum displacement 0.22369cm is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.22369cm.

2.7.8 The 20 foot high cube cargo container structure simply supported at the ceiling corners

[263] The first load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 100,000 LB distributed load on the floor is shown in FIG. 66C/D,

$100{,}000LB = 444520.16N = 44452016kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in FIG. 71D, the maximum displacement 1.5678cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.500cm.

[264] The second load condition for the 20 foot high cube collapsible cargo container frame is defined as the followings:

The 67,200 LB distributed load on the floor is shown in FIG. 66C/D,

$67{,}200LB = 298717.55N = 29871755kg \cdot cm/s^2$

For each column, 83,750 LB centralized loads applied at the floor end,

$83750LB = 372285.634N = 37228563.4kg \cdot cm/s^2$

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container frame panel structure is shown in FIG. 72D, the maximum displacement 1.0719cm is located in the floor; the maximum displacement in the floor longitudinal beams is 0.354cm.

[265] The third load condition for the modified 20 foot high cube collapsible cargo container frame panel structure is defined as the followings:

As the FIG. 61C/D and FIG. 67C/D shown, the front and back frames of the 20 foot collapsible cargo container frame panel structure have been replaced by two vertical columns, []-Beam(1), which connect the floor and ceiling longitude beams.

The total 50,000 LB centralized loads on the four floor corners are also shown in FIG. 67C/D,

$50000LB = 222260.08N = 22226008kg \cdot cm/s^2$, each corner has $5556502kg \cdot cm/s^2$.

The weight load is 4,355 LB or 1936 kg,

$1936kg \times 9.80m/s^2 = 18972.8N = 1897280kg \cdot cm/s^2$

The deformation graph of the 20 foot high cube cargo container modified frame panel structure is shown in FIG. 73D, the maximum displacement 0.22979 is located in the floor; the maximum displacement in the floor longitudinal beams is also 0.22979.

2.8 The inner force of the crossbeams

[266] 40 foot collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1A. Each beam in the front/back frame panels is labeled in FIG. 65A/B.

[267] 40 foot high cube collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1B. Each beam in the front/back frame panels is labeled in FIG 65A/B.

[268] 20 foot collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1C. Each beam in the front/back frame panels is labeled in FIG. 65C/D.

[269] 20 foot high cube collapsible cargo container frame panel structure:

The inner forces of the crossbeams in the front/back frame panels are listed in Table 1D. Each beam in the front/back frame panels is labeled in FIG. 65C/D.

2.9 The inner force of the vertical beams

[270] 40 foot collapsible cargo container:

The inner forces of the vertical beam in the front/back frame panels are listed in Table 2A. Each beam is labeled in FIG. 61A/B.

[271] For the 40 foot high cube collapsible cargo container, the inner forces of the vertical beam in the front/back frame panels are listed in the Table 2B, each beam is numbered as the FIG. 61A/B shown.

[272] For the 20 foot collapsible cargo container, the inner force of the vertical beam in the front/back frame panels is listed in the Table 2C, each beam is numbered as the FIG. 61C/D shown.

[273] For the 20 foot high cube collapsible cargo container, the inner force of the vertical beam in the front/back frame panels is listed in the Table 2D, each beam is numbered as the FIG. 61C/D shown.

2.10 Column and beam stability analysis

[274] The formula used to compute the stability of column/beam simply supported at two ends:

$$P_l = k\pi^2 \frac{EI}{l^2}, k = 1.0$$

Wher : E ——young's modulus I ——inertia moment l ——L ngth

2.10.1 Stability analysis for column (height = 8 foot 6 inch)

[275] The critical load of the column with the cross section as shown in FIG. 62

$$E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$$
$$I_x = 2.485e+003cm^4$$
$$l = 259cm$$
$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times2.485\times10^3}{259^2} = 7.7432e+008kg\cdot cm/s^2$$
$$= 7.7432e+006N = 1.7422e+006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 103 times of the maximum gross weight.

[276] The critical load of the column with the cross section as shown in FIG. 63

$$E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$$
$$I_x = 2.300e+003cm^4$$
$$l = 259cm$$
$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times2.300\times10^3}{259^2} = 7.1668e+008kg\cdot cm/s^2$$
$$= 7.1668e+006N = 1.6125e+006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 95 times of the maximum gross weight.

2.10.2 Stability analysis for column (height = 9 foot 6 inch)

[277] The critical load of the column with the cross section as shown in FIG. 62

$$E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$$
$$I_x = 2.485e+003cm^4$$
$$l = 289.56cm$$
$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times2.485\times10^3}{289.56^2} = 6.1950e+008kg\cdot cm/s^2$$
$$= 6.1950e+006N = 1.3939e+006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 82 times of the maximum gross weight.

[278] The critical load of the column with the cross section as shown in FIG. 63

$$E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$$
$$I_x = 2.300e+003cm^4$$
$$l = 289.56cm$$
$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times2.300\times10^3}{289.56^2} = 5.7338e+008kg\cdot cm/s^2$$
$$= 5.7338e+006N = 1.2901e+006LB$$

Based on the maximum gross weight 67,400 LB for the structure, the column critical load is 76 times of the maximum gross weight.

[279] The above analysis shows that four columns of the collapsible cargo container and high cube collapsible cargo container will be able to bear extremely large vertical loads.

2.10.3 Stability analysis for the crossbeams when $l = 100cm$

[280] $$E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$$
$$I_x = 11.9\, cm^4$$
$$l = 100cm$$
$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times11.9}{100^2} = 2.4874\times10^7 kg\cdot cm/s^2$$
$$= 2.4874\times10^5 N = 5.5966\times10^4 LB$$

The values for crossbeam 3 and 11 specified in Table 1A and Table 1B are below the maximum limit defined by P_l. Therefore, crossbeam 3 and 11 meet the stability requirement. The values for crossbeam 3 and 5 specified in Table 1C and Table 1D are below the maximum limit defined by P_l. Therefore, crossbeam 3 and 5 meet the stability requirement.

2.10.4 Stability analysis for the crossbeams when $l = 200cm$

[281] $$E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$$
$$I_x = 11.9\, cm^4$$
$$l = 200cm$$
$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times11.9}{200^2} = 6.2184\times10^6 kg\cdot cm/s^2$$
$$= 6.2184\times10^4 N = 1.3992\times10^4 LB$$

The values for crossbeam 6 and 8 specified in Table 1A and Table 1B are below the maximum limit defined by P_l . Therefore, crossbeam 6 and 8 meet the stability requirement.

2.10.5 Stability analysis for the vertical beam when $l = 259cm$

[282] $E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$

$I_x = 4.8\,cm^4$

$l = 259cm$

$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times4.8}{259^2} = 1.4957\times10^6 kg\cdot cm/s^2$$

$$= 1.4957\times10^4 N = 3.3653\times10^3 LB$$

The value for vertical beam 2 specified in Table 2A and Table 2B is below the maximum limit defined by P_l . Therefore, vertical beam 2 meets the stability requirement.

2.10.6 Stability analysis for the ceiling longitudinal beam simply supported at two ends when $l = 1219cm$

[283] $E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$

$I_x = 651.132\,cm^4$

$l = 1219cm$

$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times651.132}{1219^2} = 9.1592\times10^6 kg\cdot cm/s^2$$

$$= 9.1592\times10^4 N = 2.0608\times10^4 LB$$

When the collapsible cargo container frame panel structure is simply supported at four floor corners with only six vertical beams in the front and back frames to connect the floor and ceiling longitudinal beams, the ceiling longitudinal beam inner force is

$$-2.5964e+004\ N = -5.8419e+003\ LB$$

The value for ceiling longitudinal beam inner force is below the maximum limit defined by P_l . Therefore, the ceiling longitudinal beam meets the stability requirement.

2.10.7 Stability analysis for the ceiling longitudinal beam when $l = 609.6cm$ and it is simply supported at two ends

[284] $E = 212Gp = 212\times10^9 N/m^2 = 212\times10^7 kg/(s^2cm)$

$I_x = 651.132\,cm^4$

$l = 609.6cm$

$$P_l = 1.0\times3.14^2\times\frac{212\times10^7\times651.132}{609.6^2} = 3.6625\times10^7 kg\cdot cm/s^2$$

$$= 3.6625\times10^5 N = 8.2406\times10^4 LB$$

When the collapsible cargo container frame panel structure is simply supported at four floor corners with only two vertical beams in the front and back frames to connect the floor and ceiling longitudinal beams, the ceiling longitudinal beam inner force is

$-9.5011e+003N = -2.1377e+003\,LB$

Comparing P_l value with the ceiling longitudinal beam inner force value above, the ceiling longitudinal beam certainly meets the stability requirement.

3 Joint connector part analysis

3.1 Joint T pin holder analysis

[285] The joint T pin holder is shown in FIG. 74, where variable X is in the range 5cm to 7cm. Its related load condition is also as shown in FIG. 74.

Under 100,000 LB load condition, assuming the load is evenly distributed on the joint T pin holder surface:

For the joint T pin holder at the floor level, the load Px is 4.6971e+004N (10438LB), and the load Pz is 5.4e+004N (12000 LB).

For the joint T pin holder at the ceiling level, the load Px is 1.4446e+004N (3210 LB), and the load Pz is 3.0713e+004N (6813LB).

From the stress contour graph FIG. 75 and FIG. 76, the results show that the floor level joint T pin holder maximum Mises stress is 148.13MP and the ceiling level joint T pin holder maximum Mises stress is 75.37MP.

[286] Finite element analysis is conducted for the shaded part of the joint T pin holder as shown in FIG. 77. The load Px for the floor level and ceiling level shadowed part are

4.6971e+004N (10438LB) and 1.4446e+004N (3210 LB) respectively. The finite element analysis results show the floor level joint T pin holder maximum Mises stress is 166.56MP in FIG. 78 and the ceiling level joint T pin maximum Mises stress is 55.55MP in FIG. 79.

3.2 Male pin base and female pin base analysis

[287] The male pin base is shown in FIG. 80, where

x_1 = 1.75cm, x2 = 2.5cm, d = 3.0cm, $y_1 = y_2$ = 1.75cm

Less than 100,000 LB load, the load Px for the male pin base is 14050.825N (3122LB), and the load Py is 15572.25N (3460 LB), as shown in FIG. 81. From the stress contour graph FIG. 82, the results show that the male pin base maximum Mises stress is 115.62MP.

FIG. 83 and FIG. 84 show the male pin base deformation in X and Y orientation respectively.

[288] The female pin base is shown in FIG. 85, where

x_1 = 1.75cm, x2 = 2.5cm , d = 3.0cm, $y_1 = y_2$ = 1.75cm, w_1 = 4cm

Less than 100,000 LB load, the load Px for the female pin base is 7025.4125N (1561LB), and the load Py is 7786.125N (1730 LB), as shown in FIG. 86. From the stress contour graph FIG. 87, the results show that the female pin base maximum Mises stress is 77.55MP. FIG. 88 and FIG. 89 show the female pin base deformation in X and Y orientation respectively.

3.3 Pin analysis

[289] The stress analysis of the pin, which is used to connect the male pin base and female pin base, is based on the following formula

a. $$\tau = \frac{4F_l}{\pi D^2 Z}$$

where

F_l = 85000N, D = 3.5cm = 0.035m, Z = 2,

Based on the material properties defined in section 2.3,

$\tau <$ 45Mp

$\tau < \tau_p <$ 140Mp

Therefore the pin is suitable.